Fisheries and Oceans Canada | Pêches et Océans Canada
Ecosystems and Oceans Science | Sciences des écosystèmes et des océans

Canadian Science Advisory Secretariat
Science Response 2016/001

Maritimes Region

EASTERN SCOTIAN SHELF SHRIMP STOCK STATUS UPDATE FOR 2015-2016

Context

Advice on the status of the Eastern Scotian Shelf (ESS) Shrimp stock is requested annually by Fisheries and Oceans Canada (DFO) Fisheries and Aquaculture Management Branch and industry to help determine a Total Allowable Catch (TAC) that is consistent with the Integrated Fishery Management Plan (IFMP). Science advice for the management of the ESS Shrimp stock is provided as a fully peer-reviewed stock assessment at an inclusive Regional Advisory Process (RAP) meeting on a biennial basis. In interim years, science advice is provided as a stock status update and published as a Science Response. The most recent RAP took place in November 2014 (Hardie et al. 2015) and the most recent framework took place in April 2015 (Hardie et al. unpublished manuscript[1]). The current report provides information on the stock status for 2015 and advice for management of the 2016 fishery.

This Science Response Report results from the Science Response Process of December 9, 2015, on the Stock Status Update of Eastern Scotian Shelf Shrimp in Shrimp Fishing Areas (SFAs) 13-15.

Background

The expectation that the relatively abundant 2007-2008 year classes would reach the end of their life expectancy in 2014-2016, coupled with evidence that the 2009-2012 year classes were not abundant, were invoked to predict a decline in the ESS Shrimp stock in the last two stock assessments (DFO 2014, DFO 2015, Hardie et al. 2015). Despite these predictions, due to very high adult biomass, the TAC was raised to 4500 mt in 2013 and held constant in 2014, with the stated proviso that "reactive TAC reductions will be required immediately when the stock begins to show signs of the anticipated decline" (DFO 2015). The most recent cohort for which there is compelling evidence of high abundance is the 2013 year class (Hardie et al. 2015 and herein), which is not yet fully recruited to the fishing gear, and is still 2-3 years from recruiting to the spawning stock biomass.

Description of the Fishery

The trawl fishery on the Scotian Shelf occurs primarily during spring and early summer with some fishing during fall, in the deep offshore Shrimp "holes", and on an inshore area near the Bad Neighbour Shoal (Figure 1). The main management tools are limits on the number of licenses and size of vessels used, minimum codend mesh size (40 mm), use of a Nordmøre separator grate, and a TAC. This fleet (about 17 active licenses) is divided into two sectors, a midshore sector consisting of vessels 65-100' Length Over All (LOA) based in New Brunswick in the Gulf Region, and an inshore sector consisting of vessels mainly <65' LOA based in the Maritimes Region. A trap fishery, currently consisting of 8 active licenses is restricted to

[1] Hardie, D., Covey, M., and Cook, A. (2015). *2015 Eastern Scotian Shelf Shrimp Framework*. DFO Can. Sci. Advis. Sec. Res. Doc. Unpublished manuscript.

Canada

Chedabucto Bay. The allocation of quota to the Chedabucto Bay trap fishery currently stands at 8% of the TAC.

Although there has been some Shrimp fishing on the Scotian Shelf since the 1960s, the Nova Scotia fishery began to expand toward its full potential only when groundfish bycatch restrictions were overcome with the introduction of the Nordmøre grate in 1991 (Figure 2). The TAC was first reached in 1994, when individual Shrimp Fishing Area (SFAs) quotas were removed. Since that time, the TAC has fluctuated between 3100 – 5500 mt, mostly in response to the influence of strong recruitment events (large year classes) on spawning stock and fishable biomass. The TAC for 2015 was 4500 mt.

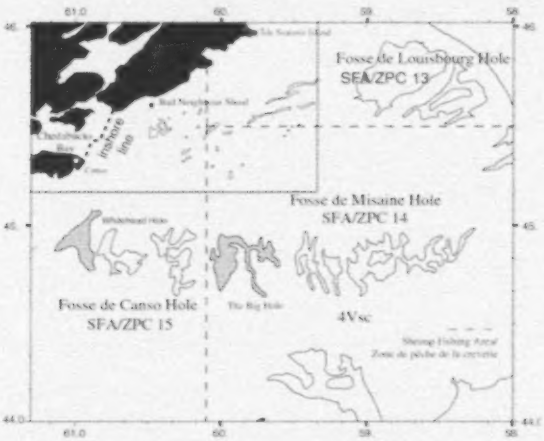

Figure 1. Shrimp Fishing Areas (SFAs) on the Eastern Scotian Shelf. The finely stippled line depicts survey stratum 17, and survey strata 13-15 are the remaining portions of SFAs 13-15.

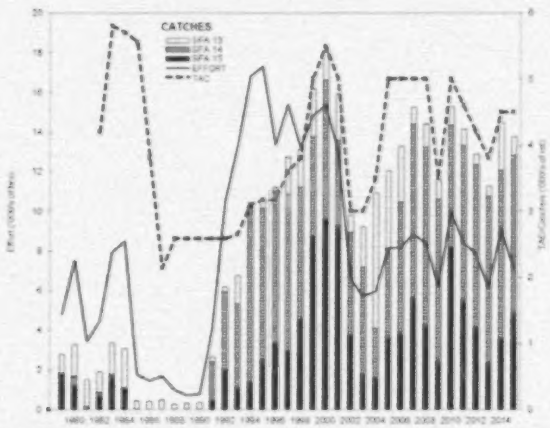

Figure 2. History of Eastern Scotian Shelf Shrimp fishery showing catches per Shrimp Fishing Areas, Total Allowable Catch, and effort up to November 15, 2015.

Analysis and Response

The stock assessment for ESS Shrimp is based on a "Traffic Light" analysis (Koeller et al. 2000, Mohn et al. 2001, Halliday et al. 2001) that uses a multiple indicator diagnostic approach, with discussion of individual indicators grouped under headings representing four "characteristics" (see Hardie et al. 2015 for the most recent full assessment).

A precautionary approach using reference points and control rules within the framework of the Traffic Light analysis has been used in recent assessments for this stock. In general, the precautionary application of reference points for ESS Shrimp includes a limit reference point (LRP) and upper stock reference (USR), which are 30% and 80% of the average spawning stock biomass (SSB) maintained during the high productivity period of the modern fishery (2000-2010) respectively. A maximum removal reference point of 20% female exploitation is used to help guide management decisions (see Hardie et al. 2015 for details and recent application).

Data used in this assessment include commercial catch data, survey catch per unit effort (CPUE) data (raised to total biomass using swept area method), detailed Shrimp biological data (commercial and survey samples), survey data for other marine species, and various environmental data (see Hardie et al. 2015 for details).

Indicators of the Stock Status

The swept area biomass index declined by 23.5% from 38,791 +/- 7542 (95% confidence interval) mt in 2014 to 29,642 +/- 7342 (95% confidence interval) mt in 2015. Biomass estimates declined in all strata except for stratum 15 (Figure 3). Generally, commercial CPUE was similar in 2015 to 2014, although the 2015 Gulf and Trap CPUEs increased while the standardized CPUE decreased. Overall, the mean normalized CPUE of commercial and survey CPUEs remained approximately stable in 2015 (Figure 4).

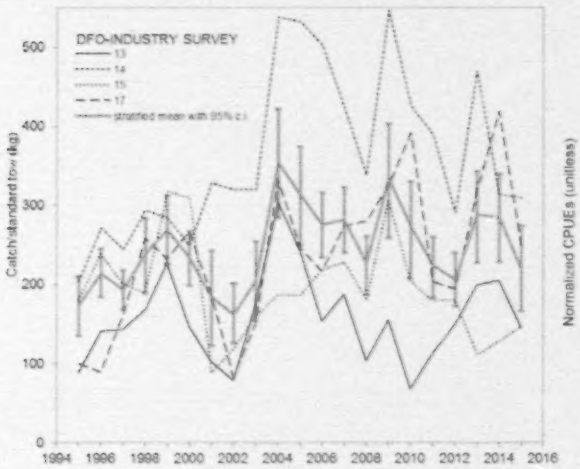

Figure 3. Survey Catch per Unit Efforts overall and by survey stratum.

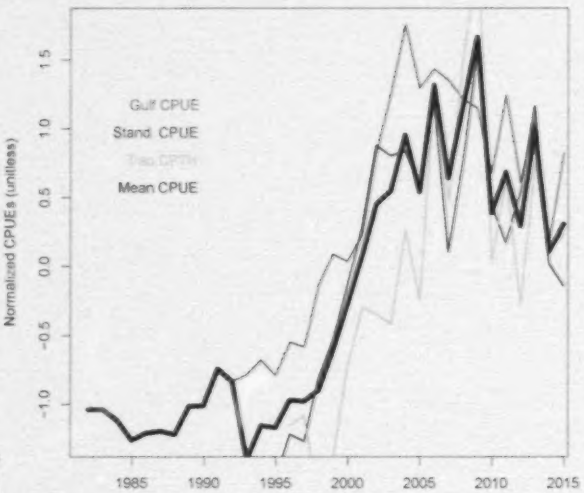

Figure 4. Mean-normalized commercial and survey Catch per Unit Efforts.

Spawning stock biomass is the biomass indicator used to define the lower and upper stock reference points as 30% and 80% of the average SSB from 2000-2010. The point estimate of the SSB decreased 26% from 20,354 mt in 2014 to 14,939 mt in 2015, just above the USR (14,558 mt). Female exploitation increased to 18.7%, just below the removal reference of 20%. However, it is important to note that uncertainty around the SSB point estimate makes it likely that the value of the SSB falls below or above the USR. The proportion of females in the total survey catch decreased from 70% in 2014 to 57% in 2015.

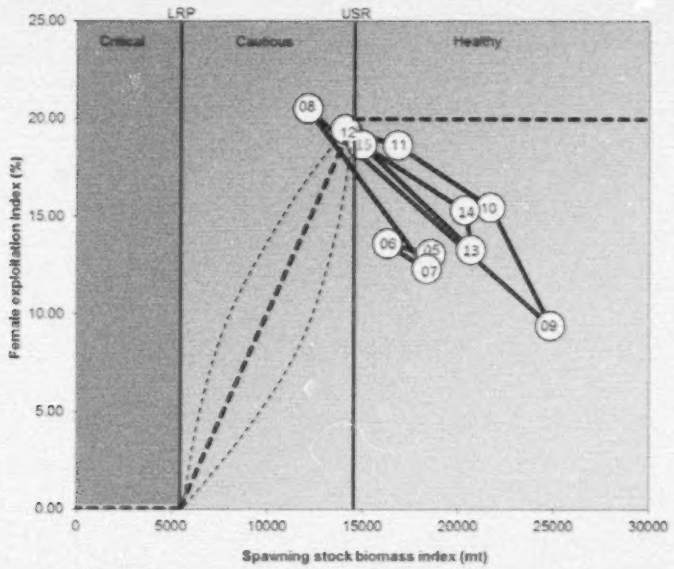

Figure 5. The precautionary approach (PA) for Eastern Scotian Shelf Shrimp showing spawning stock biomass index (PA abundance index) and female exploitation index (PA removal reference) point estimates from 2005-2015 relative to lower and upper stock reference points.

The decline in the total and spawning stock biomass indices are consistent with the expectation that the 2007-2008 year classes are reaching, or have reached, the end of their lifespan, and that the succeeding year classes (2009-2012) are not abundant. These declines are evident in decreased survey length frequencies of transitional/primiparous Shrimp in 2015 (Figure 6), although the abundance of multiparous Shrimp remained approximately stable at high abundance (Figure 6-7, Table 1). The estimated abundance of age 4 and older male Shrimp, the age at which Shrimp are expected to recruit to the female biomass the following year, is the lowest on record (Figure 7, Table 1). The abundant 2013 year class is evident in the survey length frequencies (Figure 6, Table 1) and is estimated from modal analysis to be present as the most abundant cohort of age 2 Shrimp since the very abundant 2001 year class in 2003 (Table 1). The bellybag index from the 2015 survey (the 2014 year class) is the lowest on record – similar to the 2012 year class from the 2013 survey (Table 1).

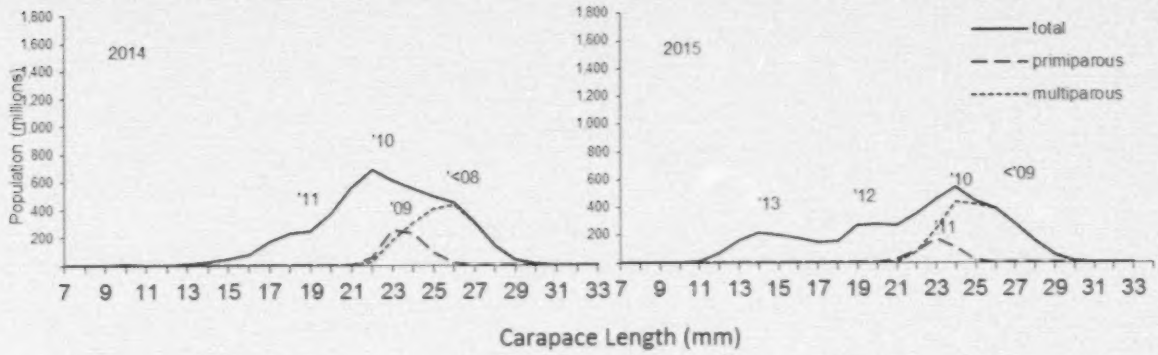

Figure 6. Population estimates of number of Shrimp at length from DFO-industry surveys 2014 and 2015 (solid line). The heavy dotted line in each figure represents transitional and primiparous Shrimp, and the stippled line represents multiparous Shrimp. See Hardie et al. 2015 for complete time-series of survey length-frequencies.

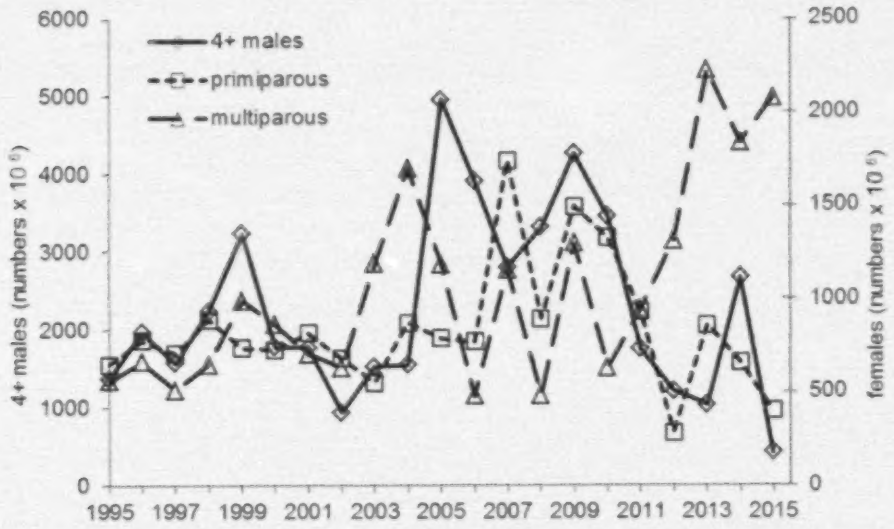

Figure 7. Population estimates of age 4 and older male, primiparous female, and multiparous female Shrimp from the survey.

Table 1. Survey population numbers at age from modal analysis. Numbers x 10^6.

	02	03	04	05	06	07	08	09	10	11	12	13	14	15	Avg.
1[4]	980	196	316	198	61	194	484	567	263	97	113	25	789	24	308
2	134	616	354	187	121	39	114	304	188	85	348	302	110	504	231
3	383	312	3118	652	880	506	396	267	1020	752	1018	1157	552	756	771
4	399	1506	839	4502	0[3]	0[3]	1190	463	1036	1044	1022	1693	0[3]	922	1416
5+	1847	1727	3324	2224	5106	5506	3017	6020	4109	2488	1666	2398	4375	1956	2888
TOTAL	2763	4161	7636	7763	6169	6244	5201	7622	6616	4467	4167	5574	5826	4162	5171
4+ males[1]	938	1526	1549	4956	3916	2804	3317	4263	3454	1755	1211	1032	2670	427	2275
Primiparous[2]	678	551	870	786	771	1739	892	1492	1324	930	281	860	659	399	835
Multiparous	630	1188	1698	1183	480	1157	482	1295	630	945	1309	2224	1835	2076	1051
Total Females	1308	1739	2568	1969	1251	2896	1374	2787	1954	1875	1590	3084	2494	2475	1886

[1] Total population less ages 2,3 males, transitionals and females; i.e. males that will potentially change to females the following year.
[2] Includes transitionals.
[3] 4 year olds of the 1996 and 2002, 2003 year classes were not distinguishable in the modal analysis. These year classes appear to be small and are contained in the age 3 or 5+ categories.
[4] Bellybag.

The most important changes in ecosystem indicators in 2015 are dramatic rises of bottom temperatures derived from the June Shrimp survey and the August groundfish survey, which are the highest on record for both time series (Figure 8). Shrimp prefer cooler temperatures (approximately 0-5 degrees Celsius) and tend to be more abundant and productive during periods and in areas of cooler bottom temperatures (Shumway et al. 1985).

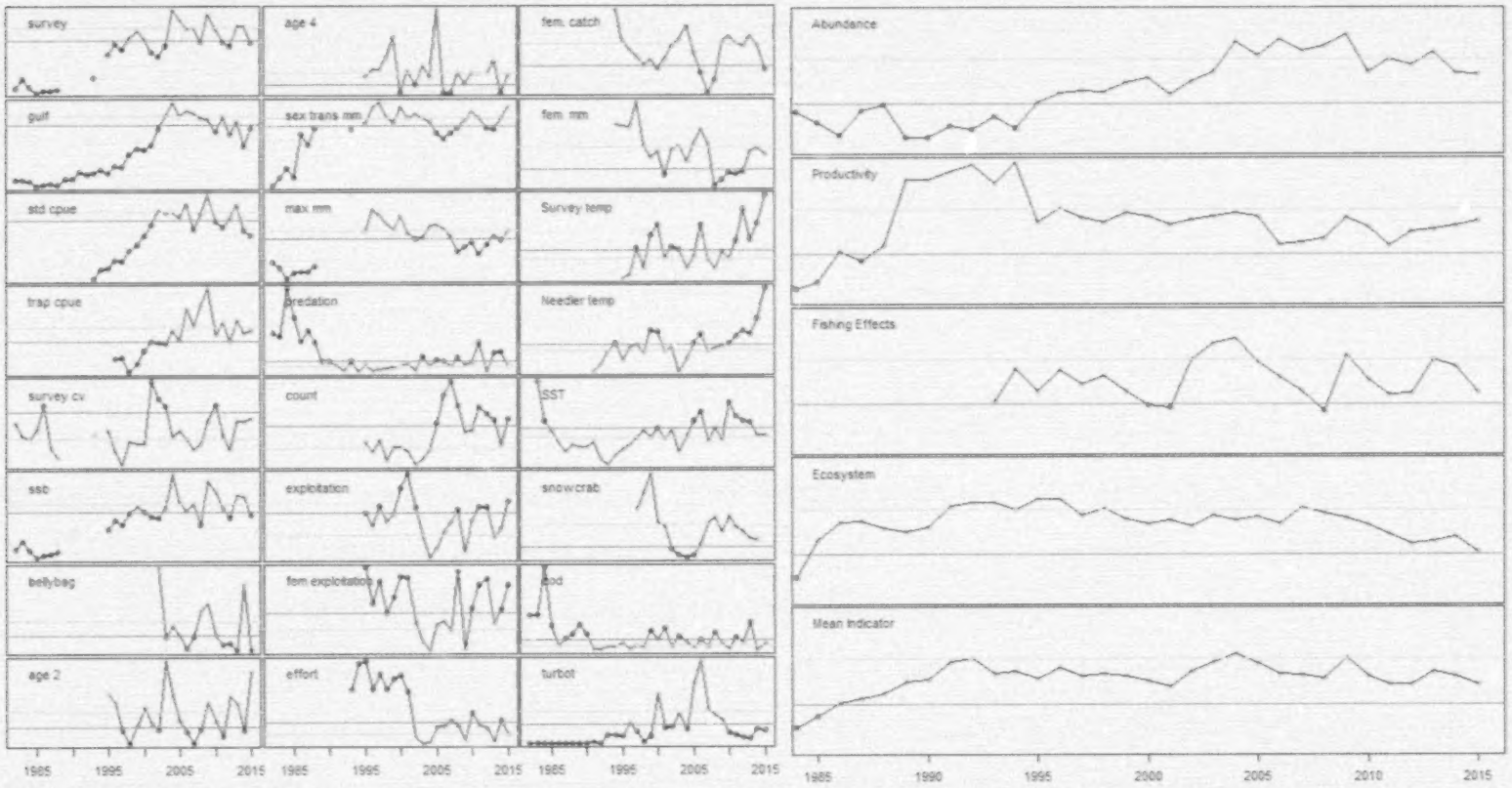

Figure 8. Time series of all available indicators (left panel), characteristics and mean (overall) indicator (right panel) time-series from 1982-2015. Thresholds between red, yellow and green are at the 33rd and 66th percentile of the 2000-2010 data series for each indicator, as was agreed at the 2015 Shrimp framework meeting. Not all indicators in the summary above are discussed in the text. See Hardie et al. 2015 for a detailed description of indicators.

Conclusions

As predicted in 2013 (DFO 2014) and 2014 (DFO 2015, Hardie et al. 2015) assessments, the ESS Shrimp stock is declining. This decline is consistent with the expectation that the abundant 2007-2008 year classes are reaching or have reached the end of their lifespan (6-8 years). Because the abundant 2013 year class, currently 2 year old males, is not yet fully recruited to the fishable biomass, the fishable stock is predominantly composed of the less abundant 2009-2012 year classes and remnants of the 2007-2008 cohorts.

The record-low estimate of age 4+ male Shrimp (pre-recruits) suggests that there will be low recruitment to the SSB in 2016. Evidence from this and recent stock assessments supports that the 2009-2012 year classes were of low abundance. This further supports that the SSB is unlikely to increase notably until the 2013 year class begins to undergo sex transition in 2017. If the 2013 year class continues to experience good survival, it would be expected to result in an increase in age 4+ males in 2017. This situation was previously observed when the similarly (to 2013) abundant 2001 year class caused a substantial increase in age 4+ males in 2005, followed by increases in female biomass in subsequent years (Figure 7). However, it should be noted that the strength of the year classes immediately preceding the 2001 year class are not known because 2002 was the first year in which a bellybag was employed on the survey. Although the 2013 year class is not expected to contribute to the SSB for another 2 years, Shrimp in this cohort are expected to increase their contribution to total biomass as they continue to grow, and to continue to spawn as males in 2016-2017.

The record-low bellybag index values in 2013 and 2015 (2012 and 2014 year classes, respectively) suggest that the recovery of the stock from the current decline will be mostly dependent on the 2013 year class. Based on the length frequencies and associated modal analysis, the 2013 year class appears to be surviving well and recruiting to the population in a manner consistent with expectations.

Recent science advice (DFO 2014, DFO 2015) has been to retain a relatively high TAC until the anticipated stock decline began, which it has. The 2015 data corroborate the high 2014 bellybag index to support that the 2013 year class is abundant and experiencing favourable survival. The abundance of this year class will likely contribute to fishable biomass in 2016 if it continues to have a high survival rate. However, the 2013 year class is not expected to contribute significantly to the SSB (precautionary approach stock indicator) until 2017. The stock is likely to decline into the cautious zone in 2016. As a result, the TAC should be reduced, particularly to conserve more of the remaining SSB until the 2013 year class begins to undergo sex transition in 2017-2018. Evidence that the 2013 year class is currently the only abundant year class expected to provide strong recruitment to the stock in the coming years, coupled with evidence of record high temperatures in the stock area in 2015 from several data sources, highlight the need for a particularly conservative harvest approach.

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